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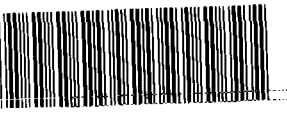

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Source/Driver: (Name & Number from ISP, IAG milestone, Mgmt. Action, Corres. Control, etc.)

Closure #: (Outgoing Correspondence Control #, if applicable)

Due Date

A. L. Primrose
Originator Name

G. DiGregorio
QA Approval

J. E. Law
Contractor Manager(s)

Lane Butler
Kaiser-Hill Program Manager(s)

A. D. Rodgers
Kaiser-Hill Director

Document Subject:

TRANSMITTAL OF THE "DRAFT TECHNICAL MEMORANDUM, MONITORING OF THE 903 PAD/RYAN'S PIT PLUME" – JEL-004-99

KH-00003NS1A

January 11, 1999

Discussion and/or Comments:

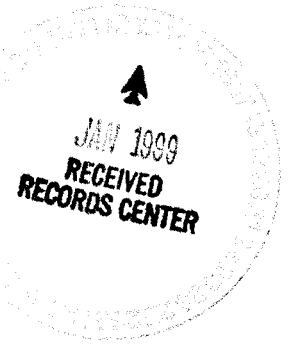
Enclosed are fourteen (14) copies of the "Draft Technical Memorandum, Monitoring of the 903 Pad/Ryan's Pit Plume" for review by the Environmental Protection Agency (EPA)(3 copies) and the Colorado Department of Public Health and Environment (CDPHE)(3 copies). This technical memorandum provides the basis and technical approach for monitoring the 903 Pad/Ryan's Pit volatile organic compound (VOC) plume to provide data on natural attenuation and to evaluate the potential for impacts to surface water quality. It is requested that comments be received by January 25, 1999. The remaining eight (8) copies are for Kaiser-Hill (4) and DOE (4) distribution.

If you have any questions concerning this information please contact Craig Cowdery at extension 2055 or Annette Primrose at extension 4385.

CDC/aw

Attachments:
As Stated

cc:
A. C. Crawford - w/o
C. D. Cowdery
A. L. Primrose
RMRS Records



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DRAFT
Technical Memorandum

Monitoring of The 903 Pad/ Ryan's Pit Plume

RF/RMRS-98-294.UN

January 1999

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DRAFT
TECHNICAL MEMORANDUM

MONITORING OF
THE 903 PAD/RYAN'S PIT PLUME

JANUARY 1999

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DRAFT TECHNICAL MEMORANDUM
MONITORING OF THE 903 PAD/RYAN'S PIT PLUME

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ACRONYMS

µg/l	micrograms per liter
AHA	Activity Hazard Analysis
Avg.	Average
CERCLA	Comprehensive Environmental Resource, Compensation, and Liability Act
CDPHE	Colorado Department of Public Health and the Environment
CFR	Code of Federal Regulations
cm/sec	centimeters per second
DNAPL	dense nonaqueous phase liquid
DOE	Department of Energy
EPA	Environmental Protection Agency
ER	Environmental Restoration
FO	Field Operations
HASP	Health and Safety Plan
HRR	Historical Release Report
IMP	Integrated Monitoring Plan
IHSS	Individual Hazardous Substance Site
MCL	Maximum Contaminant Level
mg/kg	milligram per kilogram
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PARCC	precision, accuracy, reproducibility, completeness, and comparability
PPE	personal protective equipment
QAPD	Quality Assurance Project Description
RAAMP	Radioactive Ambient Air Monitoring Program
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RMRS	Rocky Mountain Remediation Services, L.L.C.
SAP	Sampling and Analysis Plan
SID	South Interceptor Ditch
UHSU	upper hydrostratigraphic unit
VOC	volatile organic compound

1.0 INTRODUCTION

The 903 Pad/Ryan's Pit Plume originated from releases that occurred at the 903 Storage Area (Individual Hazardous Substance Site [IHSS] 112) and Ryan's Pit (IHSS 109), previously designated as a part of the former Operable Unit (OU) 2. The 903 Pad/Ryan's Pit groundwater plume was sixteenth in the priority ranking in the September 1998 Environmental Restoration (ER) Ranking. The source areas, Ryan's Pit and 903 Pad, were ranked first and sixth, respectively, in the ER Ranking. The Ryan's Pit source removal was completed in 1996 (RMRS, 1997a) and the 903 Pad source removal is scheduled for 2001. The primary contaminants in the 903 Pad/Ryan's Pit plume are carbon tetrachloride, trichloroethene, and tetrachloroethene. The Rocky Flats Environmental Technology Site (RFETS) agreed on a 1999 milestone for characterizing the plume and installing a groundwater collection and treatment system to protect surface water quality in Woman Creek.

In 1998, the RFETS program to characterize the 903 Pad/Ryan's Pit plume was approved by the Environmental Protection Agency (EPA) and Colorado Department of Public Health and the Environment (CDPHE). The characterization data showed that the contaminated groundwater plume was not affecting surface water quality and there was evidence of the occurrence of natural attenuation. As a result there was not a need for collection and treatment of contaminated groundwater in the distal end of the plume. EPA and CDPHE concurred with this conclusion and it was agreed that additional groundwater monitoring was required prior to making a final decision. This technical memorandum provides the basis and technical approach for monitoring the 903 Pad/Ryan's Pit volatile organic compound (VOC) plume to provide data on natural attenuation and to protect surface water quality.

1.1 OBJECTIVE

The objective of 903 Pad/Ryan's Pit VOC plume monitoring is to evaluate the potential for impacts on surface water quality.

Corollary Objective: Evaluate natural attenuation of the 903 Pad/Ryan's Pit Plume.

Contaminants from the 903 Pad/Ryan's Pit plume have not been detected in the nearest downstream surface water location. Additionally, the concentration and total mass of contaminants decreases considerably downgradient from the source area. VOCs have not been detected in historical samples (1986-1993) from the nearest downstream SID (SW027, see Figure 1-1). Based on these results, there does not appear to be a near-term risk to surface water quality posed by the plume. However, monitoring the plume will verify that the downgradient extent and concentrations do not impact surface water quality. Table 1-1 contains the Rocky Flats Cleanup Agreement (RFCA) (DOE, 1996) surface water action levels for Segment 5 for the contaminants of concern. These action levels are applicable at the point of evaluation, Pond C-2.

Table 1-1 RFCA Surface Water Action Levels for Segment 5 for the 903 PAD/Ryan's Pit Plume Contaminants of Concern

Compound	Surface Water Action Levels (µg/l)
Carbon Tetrachloride	5
Cis-1,2-Dichloroethene	70
Methylene Chloride	5
Tetrachloroethene	5
Trichloroethene	5

1.2 PROJECT APPROACH

The proposed action requires the installation and periodic sampling of three groundwater-monitoring wells near the leading downgradient edge of the 903 Pad/Ryan's Pit Plume. One well will replace Temporary Well 01298 (see Figure 1-1) since a permanent well is needed for long-term monitoring. Two wells will be placed downgradient. These wells will be placed in downgradient locations with the greatest groundwater flux. The locations for the downgradient wells will be based on data collected from the planned Geoprobe (direct-push sampler) boreholes. Well depths will be approximately 10 to 20 feet depending on the location. Geoprobe holes are an effective way to determine the hydrogeology of multiple locations so that wells are not placed in dry areas or areas with low groundwater fluxes. Sampling and reporting activities will be integrated with activities under the Integrated Monitoring Plan (IMP). Additional details of this approach can be found in Section 3.0.

2.0 PROJECT DESCRIPTION

This section provides a brief project background and data summary along with a description of the hydrogeologic setting and existing site conditions. More detailed information can be found in:

- *Sampling and Analysis Plan, Characterization of the 903 Pad/Ryan's Pit and East Trenches Plumes,* (IT Corp., 1998);
- *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site* (EG&G, 1995);
- *Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation (RI) Report, 903 Pad, Mound, and East Trenches Area, OU 2,* (DOE 1995), and;
- *Historical Release Report* (HRR) (DOE, 1992).

2.1 BACKGROUND

Two nearby VOC sources contribute to the 903 Pad/Ryan's Pit Plume, the 903 Pad and farther south, Ryan's Pit (Figure 1-1). The 903 Pad area was used to store drums that contained radioactively contaminated oils and VOCs from the summer of 1958 to January 1967. Approximately three-quarters of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oil, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms.

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums had leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium. From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered with clean road base and an asphalt cap. Because of the high concentrations of VOCs present in the groundwater (greater than 1% of the chemical's solubility), dense, non-aqueous phase liquids (DNAPLs) are suspected to exist underneath the 903 Pad. RFETS has scheduled remediation of the 903 Pad, including source removal, to begin in 2001.

Ryan's Pit is located approximately 150 feet south of the 903 Pad and is approximately 20 feet long, 10 feet wide, and 5 feet deep. Ryan's Pit was used as a waste disposal site starting in 1969 and for nonradioactive liquid chemical disposal starting in 1971. Use of the pit ceased in 1971. VOCs disposed at this location include tetrachloroethene, trichloroethene, and carbon tetrachloride. In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit. According to historical data, only liquids were put in the pit and their containers were either reused or disposed in other areas (DOE, 1992).

Source removal activities were completed at Ryan's Pit in 1995, including removal of contaminated soils. Along with degraded drums and plutonium-contaminated soils, free-phase tetrachloroethene and motor fuel constituents were found during this removal action. One hundred and eighty cubic yards of source material were removed in this action (RMRS, 1997a).

2.2 HYDROGEOLOGIC SETTING

The 903 Pad is located southeast of the Industrial Area of RFETS on the flat surface at the southern edge of a pediment. A south facing hillside slopes downward from the 903 Pad to the South Interceptor Ditch (SID) and Woman Creek. Ryan's Pit is located on the hillside to the south of the 903 Pad. In the 903 Pad area, the Rocky Flats Alluvium is 10 feet thick at the northwest corner of the Pad which is near a bedrock high, and 25 feet thick at the southeast corner which is within a bedrock channel. The sitewide geometric mean of the Flats Alluvium hydraulic conductivity is 6×10^{-4} centimeters/second. The Rocky Flats Alluvium is truncated by erosion and does not extend to Ryan's Pit. At Ryan's Pit and further down slope toward Woman Creek, surficial deposits principally consist of clay-rich colluvium and reworked Rocky Flats Alluvium. Caliche is common in both the alluvium and colluvium. Groundwater at Ryan's Pit is between 3 to 10 feet below ground surface. There are numerous slump features in this area and a large scarp face is located between the 903 Pad and Ryan's Pit.

Bedrock in the 903 Pad and Ryan's Pit area is primarily composed of weathered claystone of the Arapahoe and Laramie Formations. In addition, the Arapahoe No. 1 Sandstone subcrops under the alluvium at two locations, west of and southeast of the 903 Pad. The subcropping to the southeast is in the 903 Pad/Ryan's Pit Plume. Because this subcrop is in the path of groundwater flow it could affect the flow and transport of contaminants of concern in this area. The downgradient Geoprobe borings placed in 1998 did not encounter sandstone as a subcropping.

The 903 Pad/Ryan's Pit Plume is defined as the lobe of contaminated groundwater that flows southward from the two source areas toward the SID and Woman Creek drainage. The contaminants of concern are carbon tetrachloride, methylene chloride, cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene. Most of the groundwater does not daylight in this area; however, below the SID there are a number of seeps. The lobe of contaminated groundwater which flows eastward from the 903 Pad is further addressed in the East Trenches Plume Decision Document (RMRS, in progress).

The groundwater contaminant plume from the 903Pad/Ryan's Pit areas is primarily confined to the upper hydrostratigraphic unit (UHSU) which consists of Rocky Flats Alluvium, colluvium, and the weathered bedrock. Groundwater flow is complex and is primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thickness. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well defined by contact seeps with the underlying bedrock materials and by numerous wells. On the hillside, flow is affected by variations in surficial and bedrock topography and heterogeneity within the colluvium and bedrock. Areas of unsaturated colluvium and shallow bedrock are common.

Groundwater flow in the colluvium follows north-south trending preferential pathways cut into the underlying bedrock claystone. One apparent preferential pathway is approximately 150 to 300 feet wide and extends from the 903 Pad s and Ryan's Pit to approximately 1,400 feet to the southeast. At the distal end of the 903 Pad/Ryan's Pit plume, the areas lateral to this preferential pathway appear to be unsaturated.

2.3 PREVIOUS INVESTIGATIONS

Subsurface investigations, which encompassed the 903 Pad/Ryan's Pit plume, were underway as early as 1987 and include the OU 2 RCRA Facility Investigation/Remedial Investigation (RFI/RI). A 1998 investigation was implemented to provide the information necessary to design a groundwater collection and treatment system. The following information is derived from recent summaries of those investigations (DOE, 1995; RMRS, 1996).

As summarized in Section 2.2, contaminated groundwater in the 903 Pad and Ryan's Pit area is primarily confined to the UHSU. Fifty-seven VOCs have been detected in groundwater of the UHSU; of these the contaminants of concern are carbon tetrachloride, methylene chloride, cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene. In the source areas, total VOCs in the groundwater are approximately 5,000 micrograms per liter (µg/l) near the 903 Pad and approximately 57,000 µg/l near Ryan's Pit. The maximum concentrations of many VOC contaminants in the former OU 2 area are located within this plume. The highest concentration of tetrachloroethene (150,000 µg/l) was detected immediately downgradient of Ryan's Pit. A well installed through the center of the 903 Pad had groundwater concentrations of carbon tetrachloride at 20,000 µg/l, chloroform at 39,000 µg/l and methylene chloride at 35,000 µg/l. A well installed at the northeast corner of the 903 Pad detected tetrachloroethene at 14,000 µg/l (DOE, 1995). The apparent extent of the VOC plumes from the 1996 Rocky Flats Cleanup Agreement (RFCA) Groundwater Monitoring Report (RMRS, 1997b) are shown in Figures 2-2, 2-3, 2-4, and 2-5.

Migration into the Arapahoe Sandstone appears to be limited due to the lithology underlying the alluvium. The nearest subcropping of the Arapahoe No. 1 Sandstone is adjacent to the west edge of the 903 Pad. Because this subcropping occurs upgradient of the source area, the plume has had less impact to the sandstone than to other stratigraphic units. This is evidenced by a total VOC concentration in the sandstone subcropping of only approximately 2,500 µg/l. The concentrations in the Arapahoe No.1 Sandstone farther from the source areas are less than 2 µg/l or non-detectable. It is likely that claystone and silty claystone in the underlying bedrock have acted as a low permeability barrier, preventing significant quantities of contaminants from reaching the No.1 Arapahoe Sandstone.

As expected, concentrations in the distal end of the plume are lower. The concentrations of contaminants of concern in groundwater from pre-1998 wells located near the 903 Pad/Ryan's Pit downgradient plume boundary are provided in Table 2-1 and shown in Figure 2-1.

Table 2-1. Downgradient Groundwater Concentrations for Contaminants of Concern – 903 Pad/Ryan's Pit Plume

Contaminant	Well 6286	Well 6386	Well 1487	Well 23196	Well 01291	RFCA Tier II Groundwater Action Levels
Carbon Tetrachloride	8	ND	460	ND	15	5
Cis-1,2-Dichloroethene	ND	ND	ND	ND	0.2	70
Methylene Chloride	ND	ND	ND	ND	0.5	6
Tetrachloroethene	ND	ND	8	ND	2	5
Trichloroethene	0.8	ND	190	ND	12	5

Note: all values are maximum concentrations (µg/l) from 1996 sampling of monitoring wells; ND indicates not detected or below detection limit (RMRS, 1997b).

In March and April of 1998, a series of direct push (Geoprobe) borings were installed between the existing wells (Table 2-1) and the SID which is the nearest occurrence of surface water to the plume (see Figure 2-1). The boreholes were placed in a line parallel to the SID to delineate the leading edge of the plume. The boreholes were completed as temporary wells with a ¾ inch casing and screen intervals of about five feet. Groundwater levels were generally checked within one day of well installation.

The upper strata of unconsolidated sediments in these borings consisted of colluvium of various lithologies, principally silty clays and clayey silts, sometimes containing sand particles. Lenses of coarser, subangular to subrounded sands and gravels were occasionally encountered. Bedrock consists of a grayish-brown massive claystone identified by a lack of coarse-grained material. The claystone varied

from moist to very dry, often becoming drier with depth. In places, the claystone also contained abundant caliche.

The depth to bedrock varied from 2.6 feet in temporary well 02198 to 18.8 feet in temporary well 01198. The bedrock surface slopes to the southeast, in broad conformance with the surficial topography. Along the line of Geoprobe borings, localized bedrock lows occur at borings 00598, 01298, 01498, and 01698, possibly indicating the presence of south-trending preferential flow pathways (Figure 2-6). A sequence of highly weathered claystone overlying sandy silt also suggests the possibility of a slump block at this location.

Preliminary VOC analytical results for soils from the 1998 borings are presented in Table 2-2. Data validation of 25% of the data set has not been completed. Low concentrations of VOCs, primarily acetone, were detected in several of the borings. The maximum concentration of acetone was 0.072 milligram per kilogram (mg/kg) in boring 01798 is below RFCA Tier I Subsurface Soil Action Levels. The appearance of acetone in dry boreholes and boreholes away from the plume might be due to laboratory contamination since it is a common cross-contaminant. The only contaminants of concern detected were carbon tetrachloride and trichloroethene in boring 01298 below RFCA Tier I Subsurface Soil Action Levels. All other detected VOCs were below the RFCA Tier I Subsurface Soil Action Levels, which included 1,2,4-trimethylbenzene and naphthalene in boring 02098. The traces of chlorinated VOCs in 01298 soils coincide with the highest groundwater concentrations encountered in this investigation.

Groundwater was encountered in only eight of the 26 wells installed in the study area. The six westernmost wells of the alignment were dry (Figure 2-1). To the east, groundwater was intermittently encountered in the wells with the water table generally occurring within weathered bedrock. The water table slopes to the southeast, in general conformance with surficial and bedrock topography. During measurements made on June 18, 1998, the water table was observed within the colluvium in only three wells marked by locally low bedrock (01298, 01498, and 01698), with approximately three feet or less of saturated colluvium (Figure 2-1). Available data from these wells indicate that contaminated groundwater might eventually discharge to the SID and/or Woman Creek.

Sampling and analysis of the groundwater in the temporary wells was performed in accordance with the SAP, Characterization of the 903 Pad/Ryan's Pit and East Trenches Plume (IT Corp., 1998), and the appropriate RFETS Standard Operating Procedures referenced in the SAP.

Six of the 26 temporary wells installed had sufficient water to sample. Preliminary concentrations of VOCs in groundwater observed during the plume characterization investigation are presented in Table 2-3. Concentrations of three contaminants of concern (carbon tetrachloride, tetrachloroethene, and trichloroethene) are also plotted in Figure 2-1. VOCs were detected in five of the six temporary wells. The VOC concentrations in these five wells exceeded one or more Tier II Groundwater Action Levels (MCLs). Tier I Groundwater Action Levels (100 times MCLs) were not exceeded in any of the wells. In addition to the three main plume constituents, detected compounds include methylene chloride, chloroform, tetrachloroethene, cis-1,2-dichloroethene, and naphthalene. The plume is bounded on the west end by numerous dry wells and on the east end by several dry wells and one well, 01998, in which VOCs were not detected.

Table 2-2. Plume Characterization Sampling - Subsurface Soil Contaminants (mg/kg) and Corresponding RFCA Tier I Subsurface Soil Action Levels

Borehole Identification	Sampled Interval (ft bgs)	Water-Level Elevation (feet)	Acetone (mg/kg)	Carbon Tetrachloride (mg/kg)	Trichloroethene (mg/kg)
RFCA Tier I Subsurface Soil Action Level:			2,740	11	9.27
00198	14.2 – 14.5	Dry	ND	ND	ND
00298	7.4 – 7.9	Dry	ND	ND	ND
00398	10.6 – 11.4; 14.8	Dry	ND	ND	ND
00498	11.0 – 11.6	Dry	ND	ND	ND
00598	14.0 – 14.6	Dry	ND	ND	ND
00698	13.8 - 14.7	Dry	ND	ND	ND
00798	9.0 – 10.0	Dry	0.007	ND	ND
00898	13.0 – 14.0	Dry	ND	ND	ND
00998	7.3 – 7.8	5850.47	ND	ND	ND
01098	10.0 - 10.9	Dry	ND	ND	ND
01198	16.0 – 17.8	Dry	ND	ND	ND
01298	13.3 – 14.0	5840.43	ND	0.002J	0.005J
01398	4.4 – 6.5	5841.85	ND	ND	ND
01498	5.0 – 5.6	5840.16	ND	ND	ND
01598	6.6 – 7.0	Dry	ND	ND	ND
01698	14.7 – 15.5	5839.79	ND	ND	ND
01798	4.3 – 5.2	5840.18	0.072	ND	ND
01898	3.4 – 4.5	Dry	0.010	ND	ND
01998	2.0 – 2.7	Dry	ND	ND	ND
02098	?	Dry	0.020	ND	ND
02198	4.3 – 4.8	Dry	0.002J	ND	ND
02298	3.3 – 4.2	Dry	ND	ND	ND
03998	3.0 - 4.7	Dry	0.006	ND	ND
04098	4.9 – 5.5	Dry	ND	ND	ND
04198	Not sampled?	Dry	ND	ND	ND
04298	4.0 – 5.1	Dry	ND	ND	ND

J - estimated value, concentration is below the detection limit
ND – not detectable, below the detection limit of 0.006 mg/kg except for borehole 01598 which had a detection limit of 0.005 mg/kg

Table 2-3 Plume Characterization Sampling - Volatile Organic Compounds in Groundwater (μg/l)

Analyte (μg/l)	RFCA Tier II Groundwater Action Level (μg/l)	Well Identification Number					
		01298	01398	01498	01698*	01698*	01798
Methylene Chloride	5	24	10	31			
1,1-Dichloroethene	7	3 J					
Chloroform	100	96	7		73	73	32
Carbon Tetrachloride	5	460 E			150	140	13
Trichloroethene	5	500 E	9		42	40	12
Tetrachloroethene	5	0.023			8	7	2 J
Xylene (total)	100						1 J
cis-1,2-Dichloroethene	70	9			5	5	1 J
Naphthalene	1,460		6		3 J		4 J

* = Duplicate Samples
E = concentration exceeds the instrument calibration range and was diluted
J = result is estimated value below reporting limit
Blank Spaces = Not detected at detection limit of 5 ug/L
Note: Table includes only compounds detected in one or more of the samples.

2.4 EVIDENCE OF NATURAL ATTENUATION

Natural attenuation processes include "a variety of physical, chemical, and biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater" (EPA, 1997). This might include any or all of the following processes:

- Chemical Transformation,
- Biodegradation,
- Dilution,
- Dispersion,
- Sorption, and
- Volatilization

There are a number of potential mechanisms that could degrade or limit the mobility of VOCs in the 903 Pad/Ryan's Pit Plume. For the 903 Pad/Ryan's Pit Plume, all of these processes could result in significantly lower downgradient contaminant concentrations. Physical processes could be as effective as degradation in controlling contaminants. Because several of these processes likely apply to the 903 Pad/Ryan's Pit plume, the determination of a specific mechanism of attenuation is not critical. However, general conclusions regarding the evidence of natural attenuation can be made. This evidence is discussed in the following sections.

2.4.1 Plume Equilibrium

The low downgradient concentrations encountered during past investigations could be evidence that natural attenuation processes are degrading the contaminants and/or slowing the migration of contaminants. The releases that created the plume occurred between 1955 and 1971 (DOE, 1992) allowing approximately 27 to 43 years for plume migration. Well 01487, which is about 60 feet upgradient of the line of 1998 wells, shows an apparent trend of increasing carbon tetrachloride and trichloroethene concentrations over time (see Figure 2-7). Concentrations of tetrachloroethene in Well

01487 are near detection limits and appear to have no apparent trend. The gradual increase in concentration observed in Well 01487 could indicate that the VOC plume is moving slowly. Based on the concentration contaminant of concerns and their respective degradation products in downgradient wells, it appears that the predominant attenuation processes are probably the physical processes that govern the plume migration as opposed to the chemical processes that govern degradation of the contaminants. However, the slow rate of plume movement likely enhances degradation processes because the contaminants in the aquifer have a greater residence time to undergo chemical degradation.

2.4.2 Degradation Products

The presence of degradation products is an important indicator of contaminant-destroying chemical and biological processes. One difficulty in ascertaining the presence of degradation products is the wide variety of organic solvents known to have been placed into Ryan's Pit (i.e. expected degradation products could be solvents from the original release). Table 2-4 presents some of the contaminants of concern for the 903 Pad/Ryan's Pit Plume and their associated degradation products. 1,1,1-Trichloroethane was included in the analysis because it is found in Well 07391 in the Ryan's Pit source area. Concentrations of up to 1,100 ug/l of 1,1,1-Trichloroethane have been detected in the source area; however it does not appear that it is affecting downgradient groundwater. Because of high concentrations in the source area, most of the trichloroethene is probably residual solvent from the source area as opposed to a decay product from tetrachloroethene.

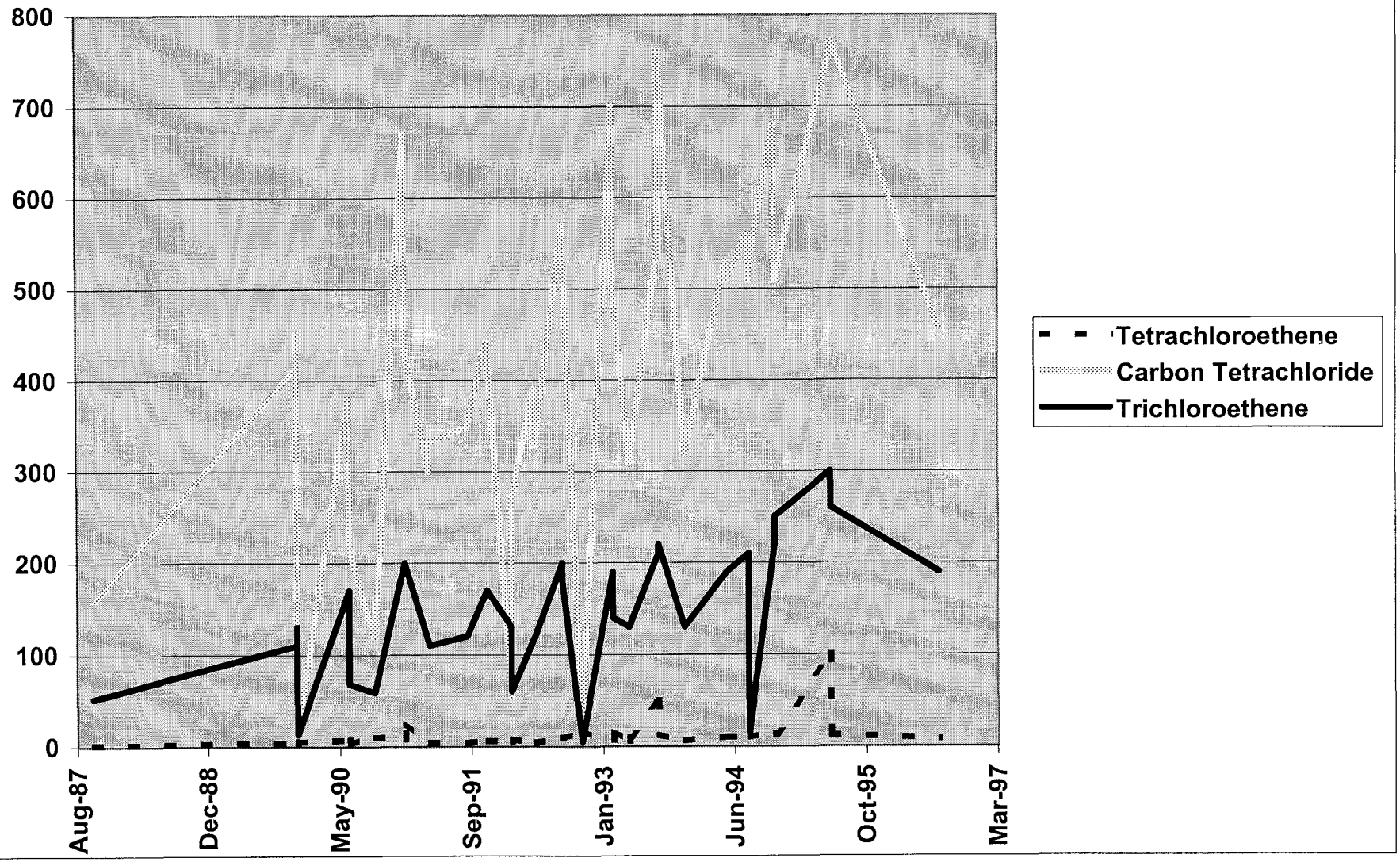
Table 2-4 Key VOCs and Associated Degradation Products in the 903 Pad/Ryan's Pit Plume

Key Contaminant	Degradation Product	Maximum Concentration in 1998 Downgradient Wells (ug/l) *	Maximum Concentration in Well 01487 (ug/l) (1987-1996)
Carbon Tetrachloride		460	770
	Chloroform	96	55
	Methylene Chloride **	31	17
	Chloromethane	Not Detected	Not Detected
1,1,1-Trichloroethane * **		Not Detected	1.06
	1,1–Dichloroethane	Not Detected	Not Detected
	Chloroethane	Not Detected	Not Detected
Trichloroethene		500	300
	Dichloroethene **	9	5
	Vinyl Chloride	Not Detected	Not Detected
Tetrachloroethene		23	15
	Trichloroethene	500	300
	Dichloroethene	9	5
	Vinyl Chloride	Not Detected	Not Detected

* Wells 01298, 01398, 01498, 01698, 01798, and 01998, maximums based on detection in at least two of these wells.
** Dichloroethene and methylene are contaminants of concern and potential degradation products.
*** 1,1,1- Trichloroethane was detected in the source area but not the in the 1998 wells.

Based on Table 2-4, degradation products for three of the contaminants of concern appear to be present in both locations. The degradation products found are all consistent with hydrogenolysis as a reductive dechlorination reaction. Hydrogenolysis is a destructive hydrogenation reaction where hydrogen replaces

Figure 2-7 VOC Concentration (ug/l) in Well 01487 Versus Time



the chlorine atom. Although these reaction products are strong indicators of reductive dechlorination, the much higher concentrations of the source area contaminants of concern indicates that reductive degradation is not a major factor in limiting the plume movement.

2.4.3 Hydrogeologic Factors

Because the study area is poorly saturated and the wells at the west end of the study area were dry (Figure 2-1), it can be concluded that the predominant factor limiting the VOC plume extent appears to be site hydrogeology. Groundwater flow is confined to the east side of the study area, possibly because of the effect of past slumping. Additionally, the bedrock surface is known to have erosional features that will further affect the flow. These subsurface features might have lengthened the flow path of the plume and enhanced attenuation of the plume through physical processes. Figure 2-8 shows the primary flow path for the contaminated groundwater. This area is also characterized by intermittent seeps from both the bedrock and the alluvium. The combination of heterogeneous permeabilities, areas of low permeability and depressions in bedrock could have routed the flow of water to the eastern portion of the study area, farther down the SID, and possibly limited contaminant migration to surface water.

2.4.4 Surface Water Quality Impacts

There is no historical evidence of surface water quality impacts from the plume. Based on data in the RFETS Soil and Water Database, VOCs have been sporadically detected in the SID at concentrations less than 100 µg/l. The source of these contaminants cannot be tied into 903 Pad /Ryan's Pit Plume since VOCs have also been detected in the SID upstream of the plume. The downstream sampling station located in the SID where it discharges into C-2 pond (SW027, Figure 1-1) was sampled for VOCs approximately 21 times between 1986 and 1993. During this time period, methylene chloride was measured at concentrations of 14 µg/l or less. Carbon tetrachloride, tetrachloroethene, and trichloroethene were at or below their detection limit of 5 µg/l. Since methylene chloride is a common laboratory contaminant and because the other contaminants of concern or their degradation products have not appeared in these proximal downstream surface water locations, there is presently not an evident impact to surface water quality. Also, further down slope from the SID, the contaminants of concern or degradation products associated with the 903 Pad/Ryan's Pit Plume have not been detected.

2.4.5 Conclusions Concerning Natural Attenuation in the 903 Pad/Ryan's Pit Plume

The following conclusions can be made based on existing data:

- Concentrations of contaminants at the leading edge of the plume need to be monitored to substantiate the evidence that natural attenuation is occurring, to assess trends in the concentration of VOCs in the groundwater, and to confirm that plume migration is not occurring or that the plume is moving very slowly.

- The presence of reductive dechlorination products of the three contaminants of concern suggests that small quantities from the original release might have been degraded. The potential degradation products appear to be consistent with the same degradation mechanism, specifically, hydrogenolysis.

- Hydrogeologic factors appear to have a greater impact on contaminant migration than degradation processes.

- There is no evidence that the 903 Pad/Ryan's Pit Plume is currently impacting surface water quality at this time.

3.0 PROPOSED ACTION

Based on a review of existing data, RFETS, EPA, and CDPHE agreed that monitoring would be the best approach for 903 Pad/Ryan's Pit Plume to assess natural attenuation and potential groundwater impacts to surface water quality. It is also recognized that source removal at the 903 Pad will address the source area contamination and reduce the influx of additional contaminants into the groundwater.

3.1 PROPOSED APPROACH

The proposed approach for monitoring the 903 Pad/Ryan's Pit Plume will be to install three downgradient permanent wells to monitor VOCs. One permanent well meeting RFETS monitoring well standards will be placed near Temporary Well 01298 (Figure 3-1). This location was selected based on mass flux calculations (IT, 1998b) presented in Appendix A. Based on the 1998 well data, this well consistently had the highest contaminant load for each of the chlorinated solvents thus the greatest contaminant mass flux.

Two additional wells will be placed downgradient of the 1998 wells and upgradient of the SID. The location of these wells will be determined by using the observational approach, i.e. Geoprobe holes will be placed to determine which locations have the greatest groundwater flow based on saturated thickness, hydraulic gradient, bedrock contours, and other hydrogeological attributes. Figure 3-1 shows the general area where Geoprobe holes will be placed. Prior to performing the fieldwork, an ecological evaluation will be conducted to make sure the work does not result in detrimental ecological effects including impacts to the Preble's Jumping Field Mouse.

Geoprobe locations and permanent wells will be monitored for VOCs. All activities will be integrated with existing RFETS monitoring activities under the IMP (Kaiser-Hill, 1997). Monitoring is planned to continue until enough data are collected to establish a trend in downgradient concentrations. Further details on data quality objectives, sampling procedures, and analytical methods will be presented in the SAP appendix to the workplan to be developed under the IMP. Monitoring will be initially performed quarterly in conjunction with the IMP activities for a year after which is will be done annually. The same sampling and analyses methodologies used for monitoring RFCA groundwater wells will be utilized for the 903 Pad/Ryan's Pit Plume wells. If at any time during monitoring, the monitoring data indicates that the plume could cause surface water concentrations to exceed the values in Table 1-1 at the point of evaluation (SW027) then the approach to 903 Pad/Ryan's Pit Plume will have to be reevaluated.

3.2 WORKER HEALTH AND SAFETY

This project falls under the scope of the Occupational Safety and Health Administration (OSHA) construction standard for Hazardous Waste Operations and Emergency Response, 29 Code of Federal Regulations (CFR) 1910.120. Under this standard, the Health and Safety Plan (HASP) currently utilized for groundwater monitoring will be revised, if necessary, to address the safety and health hazards of each phase of monitoring activities and specify the requirements and procedures for employee protection. In addition, the DOE Order for Construction Project Safety and Health Management, 5480.9A, applies to this project. This order requires the preparation of Activity Hazard Analyses (AHAs) to identify each task, the hazards associated with each task, and the precautions necessary to mitigate the hazards. The AHAs will be included in the HASP. This project could expose workers to physical and chemical hazards. Physical hazards include those associated with use of drilling equipment, noise, heat stress, and cold stress. Chemical hazards include exposure to the contaminated groundwater. Physical hazards will be mitigated by engineering controls, administrative controls, and appropriate use of personal protective equipment (PPE). Chemical hazards will be mitigated by the use of PPE and administrative controls. Appropriate

skin and respiratory PPE will be worn throughout the project. Routine VOC monitoring will be conducted with an organic vapor monitor.

If unanticipated hazards or conditions are encountered during this project in accordance with RMRS policy (Directive-001), the project activities will pause to assess the potential hazard or condition to determine whether work can proceed with existing safety controls. If field conditions or hazards vary from the planned approach and it is determined that work can be done safely, an AHA will be prepared or modified to address the unexpected circumstances, and work will proceed according to the appropriate control measures. Data and safety controls will be continually evaluated. Field radiological screening will be conducted as appropriate using radiological instruments appropriate to detect surface contamination and airborne radioactivity. As required by 10 CFR 835, Radiation Protection of Occupational Workers, all applicable implementing procedures will be followed to insure protection of the workers, collocated workers, the public, and the environment. The HASP will describe the air monitoring to be used to monitor for radiation, VOCs, and particulate, as appropriate. If necessary, air monitoring will be performed in accordance with applicable procedures, which includes perimeter Radioactive Ambient Air Monitoring Program (RAAMP) monitoring throughout the project duration. Air monitoring activities may vary and are dependent on field activities.

3.3 WASTE MANAGEMENT

Waste anticipated from drilling and sampling include drill cuttings, purge water, PPE, and development water from well installation. All wastes will be managed in accordance with the RFETS standard operating procedure, Field Operations (FO).29, for IDM under the existing IDM program. Wastes generated, as part of this proposed action, will be characterized based on process knowledge, analytical results, and radiological screening. Based on FO.29, wastes, such as PPE, identified as non-radiological and non-hazardous will be disposed in a sanitary landfill. Purge water will be treated at the 891 Consolidated Water Treatment Facility.

4.0 IMPLEMENTATION SCHEDULE

Well installation is scheduled to be completed in Fiscal Year 1999. The downgradient monitoring of the 903 Pad/Ryan's Pit Plume is scheduled to commence in the Fiscal Year 1999 on a quarterly basis. Monitoring will be reduced to an annual basis after one year of quarterly samples.

5.0 REFERENCES

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IT Corp., 1998, *Sampling and Analysis Plan, Characterization of the 903 Pad/Ryan's Pit and East Trenches Plumes*

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RMRS, 1997a, *Closeout Report for the Remediation of Individual Hazardous Substance Site 109, Ryan's Pit*, RF-ER-96-0034.UN, Revision 0, July.

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Appendix A

Estimate of Contaminant Flux for

903 Pad/Ryan's Pit Plum

By ZHT Date 7/15/98 Subject Estimation of Contaminant Flux
Chkd By Date 903 Pad/Ryan's Pit Plume, RFETS

PURPOSE:
Estimate the flux of contaminants from the distal, downgradient portion of the 903 Pad/Ryan's Pit Plume potentially entering surface water in the Woman Creek drainage.

METHODOLOGY:
The alignment of push-probe wells installed in 1998 north of Woman Creek and the South Interceptor Ditch forms the basis of the estimate. All groundwater on the steep south-facing slope above the elevation of the creek bed is assumed to discharge to the surface via seeps.

Transmissivity and concentrations in those wells within the distal portion of the plume are used to calculate the average contaminant loads in colluvium and weathered bedrock. Together with hydraulic conductivity and the length of the plume perpendicular to its flow direction, the flux of the contaminant VOCs are calculated.

ASSUMPTIONS:

In the lower portion of the Woman Creek drainage, groundwater flows horizontally out of colluvium and weathered bedrock, discharging to the surface water system. Discharge from bedrock is assumed to be limited to the first 10 feet of saturated bedrock, or the full saturated thickness between top of saturated bedrock and the creekbed elevation along a given point's downgradient flowpath, whichever is greater.

VOC plume concentrations are uniform vertically through the colluvium and weathered bedrock.

The horizontal hydraulic gradient is uniform through the plume along the alignment, and is uniform vertically through colluvium and weathered bedrock.

The following geometric means of hydrogeologic units within RFETS are assumed to be representative:

Colluvium	9.3E-05 cm/sec	2.6E-01 ft/day
Weathered claystone bedrock	8.8E-07 cm/sec	2.5E-03 ft/day

Loss or destruction of contaminants through evapotranspiration, biodegradation, and other processes is not considered. All contaminants at the alignment of the push-probe wells are conservatively assumed to enter the surface water drainage.

CALCULATIONS:
See following sheets.

CONCLUSIONS:
Flow and contaminant flux in the weathered bedrock is negligible. The colluvium is inconsistently saturated, and the distal portion of the plume transmits little flow and contaminants to the Woman Creek drainage.

Well	Elevation above MSL (feet) 6/18/98 Groundwater	Top of Bedrock	Creekbed on Flowpath	Saturated Thickness Colluvium (ft)	Bedrock Type [1]	Saturated Thickness Bedrock (ft) [2]	Transmissivity Colluvium sq.ft./day	Transmissivity Bedrock sq.ft./day	
01298	5840.43	5837.5	5834	2.90	CS	10.0	7.6E-01	2.5E-02	
01398	5841.85	5844.1	5832	0.00	CS	10.0	0.0E+00	2.5E-02	In
01498	5840.16	5839.9	5828	0.20	CS	11.9	5.3E-02	3.0E-02	Plume
01698	5839.79	5836.6	5822	3.20	CS	14.6	8.4E-01	3.6E-02	
01798	5840.18	5841.9	5821	0.00	CS	19.2	0.0E+00	4.8E-02	
					In-Plume Average T		3.3E-01	3.3E-02	

dh/dl = 0.053 Horizontal hydraulic gradient, from 6/18/98 groundwater elevations in wells 1487, 01398, 01498
L = 400 ft Estimated plume length, perpendicular to flow.

Q = KA(dh/dl)
Q = TL(dh/dl) Using average in-plume Transmissivity (T) values above:

	Flow in cu.ft./day Colluvium	Bedrock	Total
Q =	7.0	0.69	7.7

Average groundwater velocities (v) within plume:
v= K(dh/dl)/n where effective porosity n is assumed to be 0.1.

	Velocity in ft./day Colluvium	Bedrock
v =	0.14	0.0013

	Colluvium	Bedrock
Time (years) to travel 350 feet (distance on flowpath from 01298 to creek =	6.9	725.2

Footnotes:

1 Bedrock type: CS = Weathered claystone (encountered in all alignment borings)
2 Saturated bedrock thickness considered is 7 feet (consistent with practicable depth of barrier emplacement).

Well	RIN	Event	Bottle	Concentration in ug/L								
				Methylene Chloride	1,1-Dichloroethene	Chloroform	Carbon Tetrachloride	Trichloroethene	Tetrachloroethene	cis-1-2-Dichloroethene	Napthalene	
01298	98A1951	002	001	24	3	98	460	500	23	9	U	
01398	98A2143	004	002	10	U	7	U	9	U	U	6	In
01498	98A1951	003	001	31	U	U	U	U	U	U	U	Plume
01698	98A2143	002	002	U	U	73	150	42	U	U	3	
01798	98A2143	003	002	U	U	32	13	12	U	U	4	
01998	98A2143	001	002	U	U	U	U	U	U	U	U	

Well	RIN	Event	Bottle	Tier I (100 times MCL) and Tier II (1 times MCL) Action Level Exceedances (MCLs are shown immediately below)								
				5 Methylene Chloride	7 1,1-Dichloroethene	100 Chloroform	5 Carbon Tetrachloride	5 Trichloroethene	5 Tetrachloroethene	70 cis-1-2-Dichloroethene	#N/A Napthalene	
01298	98A1951	002	001	>1x	<	<	>1x	>1x	>1x	<		
01398	98A2143	004	002	>1x	--	<	--	>1x	--	--		In
01498	98A1951	003	001	>1x	--	--	--	--	--	--		Plume
01698	98A2143	002	002	--	--	<	>1x	>1x	--	--		
01798	98A2143	003	002	--	--	<	>1x	>1x	--	--		
01998	98A2143	001	002	--	--	--	--	--	--	--		

Note: The plume extent, as defined above, incorporates all exceedances of Tier II action levels along the alignment.

Well	RIN	Event	Bottle	Colluvium Contaminant Load in g/day/ft: Methylene Chloride	1,1-Dichloroethene	Chloroform	Carbon Tetrachloride	Trichloroethene	Tetrachloroethene	cis-1-2-Dichloroethene	Napthalene	Total VOCs
01298	98A1951	002	001	5.2E-04	6.5E-05	2.1E-03	1.0E-02	1.1E-02	5.0E-04	1.9E-04	0.0E+00	2.4E-02
01398	98A2143	004	002	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
01498	98A1951	003	001	4.6E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-05
01698	98A2143	002	002	0.0E+00	0.0E+00	1.7E-03	3.6E-03	1.0E-03	0.0E+00	0.0E+00	7.2E-05	6.4E-03
01798	98A2143	003	002	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Average				1.1E-04	1.3E-05	7.6E-04	2.7E-03	2.4E-03	1.0E-04	3.9E-05	1.4E-05	6.1E-03

Well	RIN	Event	Bottle	Bedrock Contaminant Load in g/day/ft: Methylene Chloride	1,1-Dichloroethene	Chloroform	Carbon Tetrachloride	Trichloroethene	Tetrachloroethene	cis-1-2-Dichloroethene	Napthalene	Total VOCs
01298	98A1951	002	001	1.7E-05	2.1E-06	6.8E-05	3.3E-04	3.5E-04	1.6E-05	6.4E-06	0.0E+00	7.9E-04
01398	98A2143	004	002	7.1E-06	0.0E+00	4.9E-06	0.0E+00	6.4E-06	0.0E+00	0.0E+00	4.2E-06	2.3E-05
01498	98A1951	003	001	2.6E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-05
01698	98A2143	002	002	0.0E+00	0.0E+00	7.5E-05	1.5E-04	4.3E-05	0.0E+00	0.0E+00	3.1E-06	2.8E-04
01798	98A2143	003	002	0.0E+00	0.0E+00	4.3E-05	1.8E-05	1.6E-05	0.0E+00	0.0E+00	5.4E-06	8.3E-05
Average				1.0E-05	4.2E-07	3.8E-05	9.9E-05	8.4E-05	3.3E-06	1.3E-06	2.6E-06	2.4E-04

Well	RIN	Event	Bottle	Total Contaminant Load in g/day/ft: Methylene Chloride	1,1-Dichloroethene	Chloroform	Carbon Tetrachloride	Trichloroethene	Tetrachloroethene	cis-1-2-Dichloroethene	Napthalene	Total VOCs
01298	98A1951	002	001	5.4E-04	6.7E-05	2.1E-03	1.0E-02	1.1E-02	5.1E-04	2.0E-04	0.0E+00	2.5E-02
01398	98A2143	004	002	7.1E-06	0.0E+00	4.9E-06	0.0E+00	6.4E-06	0.0E+00	0.0E+00	4.2E-06	2.3E-05
01498	98A1951	003	001	7.2E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.2E-05
01698	98A2143	002	002	0.0E+00	0.0E+00	1.8E-03	3.7E-03	1.0E-03	0.0E+00	0.0E+00	7.5E-05	6.7E-03
01798	98A2143	003	002	0.0E+00	0.0E+00	4.3E-05	1.8E-05	1.6E-05	0.0E+00	0.0E+00	5.4E-06	8.3E-05
Average				1.2E-04	1.3E-05	8.0E-04	2.8E-03	2.4E-03	1.0E-04	4.0E-05	1.7E-05	6.4E-03

X = TC g/day/ft Contaminant load equals transmissivity times concentration
Unit conversion: T(sq.ft/day) x C (ug/L) x 28.32 L/cu.ft x 10-6 g/ug =TC (g/(day/ft)
T is taken from the values calculated for both colluvium and bedrock at individual wells on the "Flow" sheet
C is from the table of concentrations on the "Concentration" sheet

Contaminant Flux
903 Pad/Ryan's Pit Plume

	Contaminant Flux in g/day								
	Methylene Chloride	1,1-Dichloroethene	Chloroform	Carbon Tetrachloride	Trichloroethene	Tetrachloroethene	cis-1-2-Dichloroethene	Napthalene	Total VOCs
Colluvium	2.4E-03	2.8E-04	1.6E-02	5.7E-02	5.0E-02	2.1E-03	8.3E-04	3.0E-04	1.3E-01
Bedrock	2.1E-04	9.0E-06	8.1E-04	2.1E-03	1.8E-03	6.9E-05	2.7E-05	5.4E-05	5.1E-03
Total	2.6E-03	2.8E-04	1.7E-02	6.0E-02	5.2E-02	2.2E-03	8.5E-04	3.6E-04	1.3E-01

F = Q C — Contaminant Flux equals flow times concentration

F = [TL(dh/dl)]C

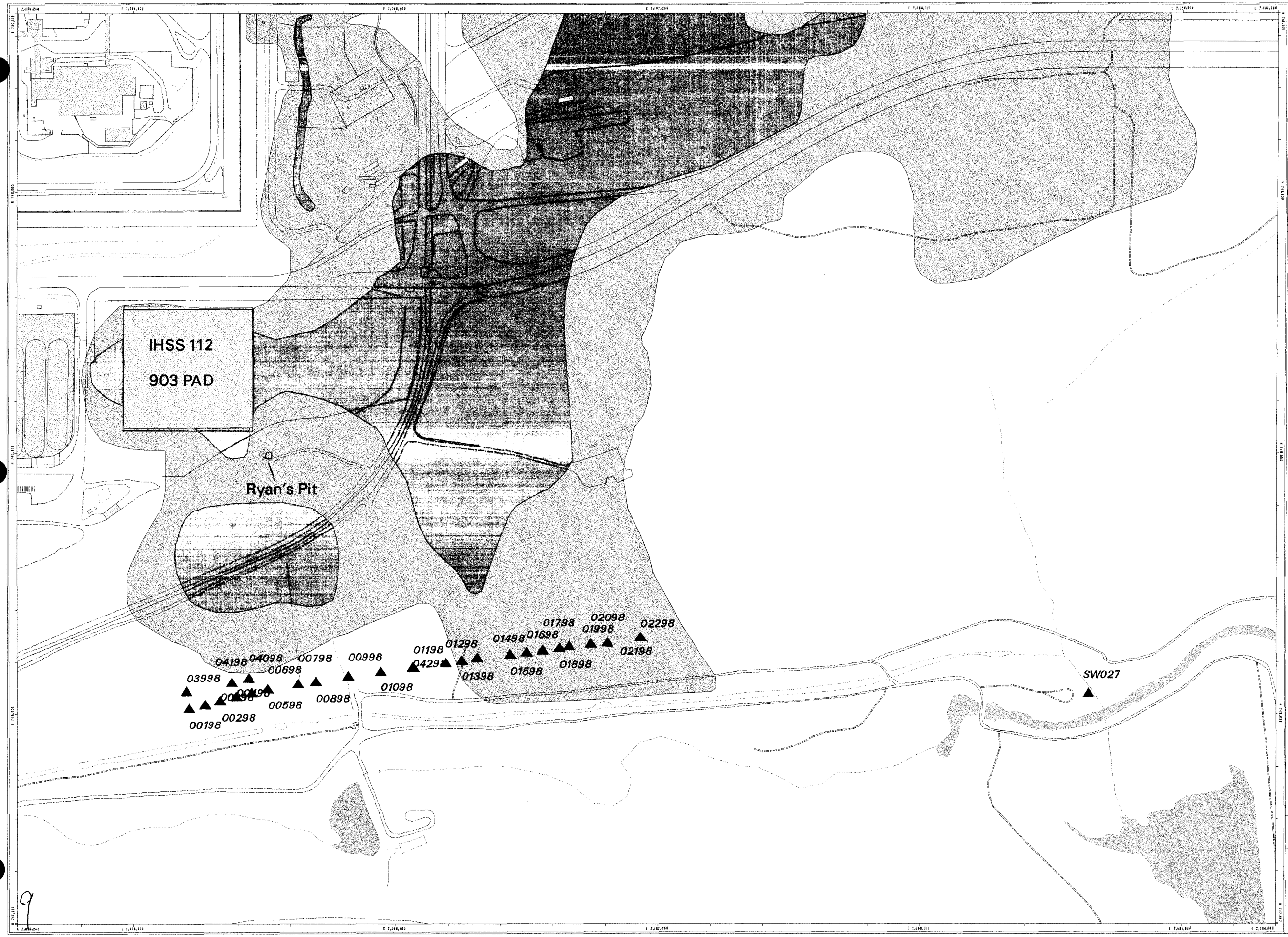
F = XL(dh/dl) — Contaminant Flux equals Contaminant Load times Length times hydraulic gradient

dh/dl = 0.053 — Horizontal hydraulic gradient, from 6/18/98 groundwater elevations in wells 1487, 01398, 01498

L = 400 ft — Estimated plume length, perpendicular to flow.

X is taken from the average values calculated for colluvium and bedrock on the "Load" sheet

Figure 1-1
903 Pad/Ryan's Pit
Plume Location Map



EXPLANATION

- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- SW027
- Temporary wells installed in 1998

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial flyover data captured by RMRS RSI, Las Vegas.
Digitized from the orthophotographs, 1/95

Scale = 1 : 3450
1 inch represents approximately 288 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0105

January 07, 1999

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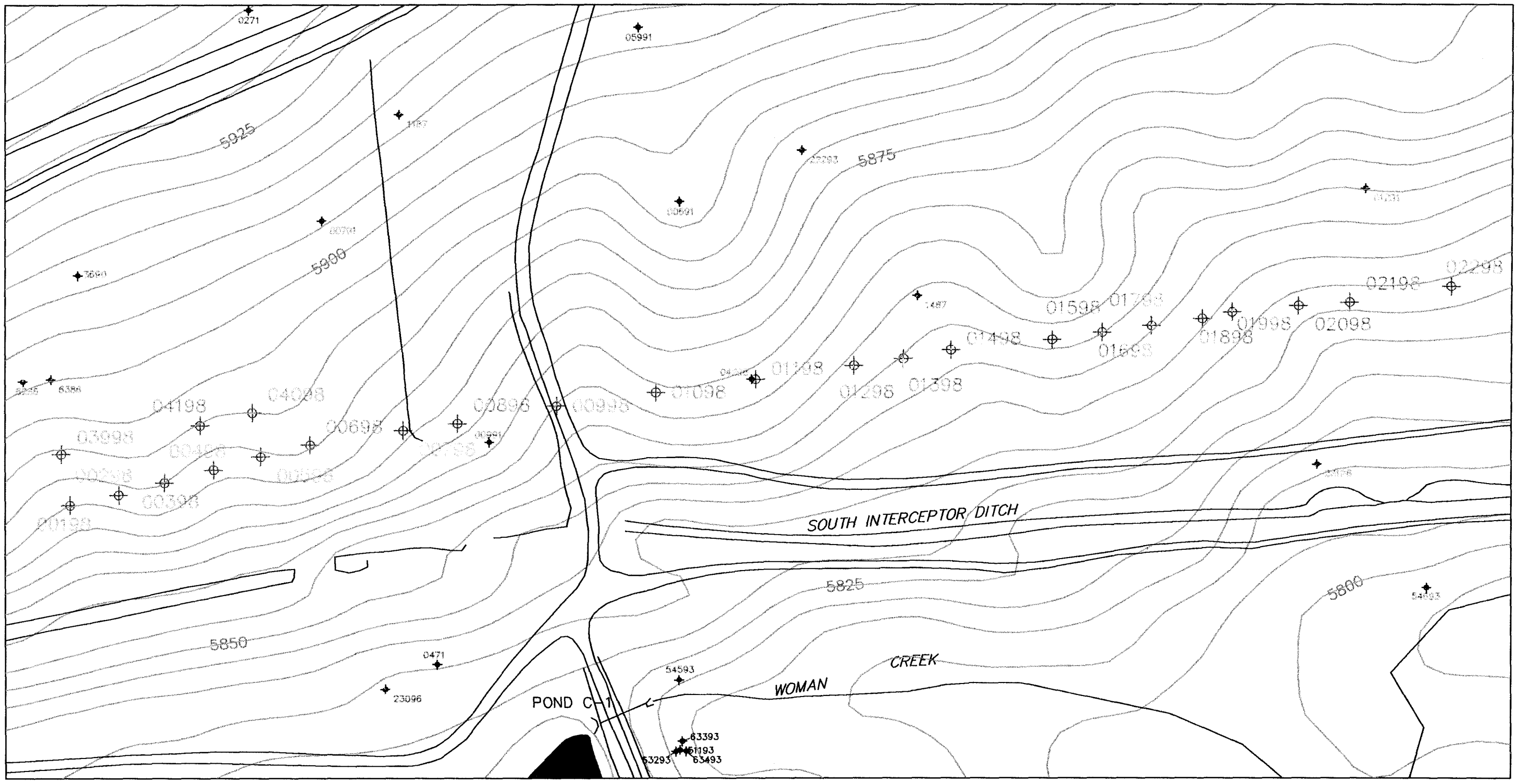

LEGEND

- LAKES AND PONDS
- STREAMS AND DITCHES
- 5 FOOT CONTOUR
- FENCE OR OTHER BARRIER
- DIRT ROAD
- 00898 — SAMPLED WELL LOCATION (INSTALLED 1998)
- 00991 — EXISTING DATA LOCATION

GRAPHIC SCALE
0 25 50 100
(IN FEET)
1 inch = 100 ft.

VOC CONCENTRATIONS IN GROUNDWATER, ug/L

NOTE: PCM = CARBON TETRACHLORIDE (PERCHLORMETHANE)
PCE = TETRACHLOROETHENE (PERCHLOROETHYLENE)
TCE = TRICHLOROETHENE
U = NOT DETECTED

DRY=NOT SAMPLED (NO WATER)
NS=NOT SAMPLED (INSUFFICIENT WATER)

PREPARED FOR:
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
Golden, Colorado

FIGURE 2-1

TITLE:

VOC's IN GROUNDWATER
AT THE 903 PAD/RYAN'S PIT
PLUME STUDY AREA

99-0066/figure2-1

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Figure 2-2
Trichloroethene Concentration in Groundwater, 1991-1997 (Avg.)

EXPLANATION

- Trichloroethene concentration equal to or greater than 5 ug/L
- Trichloroethene concentration equal to or greater than 500 ug/L

Trichloroethene Concentration (ug/L)

- Undetected
- 0 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 100
- 100 - 500
- > 500
- Alluvial Wells
- Bedrock Wells
- Alluvial/Bedrock Wells

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by ESRI PSL, Las Vegas. Digitized from the orthophotographs. 1/96 Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. The DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 2300
1 inch represents approximately 192 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 98-0066 January 05, 1998

/gis2/projects/hy98/98-0066/ac_toe_plume.aml

Figure 2-3
Carbon Tetrachloride Concentration in Groundwater 1991-1997 (Avg.)

EXPLANATION

- Carbon Tetrachloride concentration equal to or greater than 5 ug/L
- Carbon Tetrachloride concentration equal to or greater than 500 ug/L

Carbon Tetrachloride Concentration (ug/L)

- Undetected
- 0 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 100
- 100 - 500
- > 500
- Alluvial Wells
- Bedrock Wells
- Alluvial/Bedrock Wells

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas.
Digitized from the orthophotographs, 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Mortenen Knudson (M/K) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. The DEM post-processing performed by M/K, Winter 1997.

Scale = 1 : 2300
1 inch represents approximately 192 feet

0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

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Prepared by:

Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

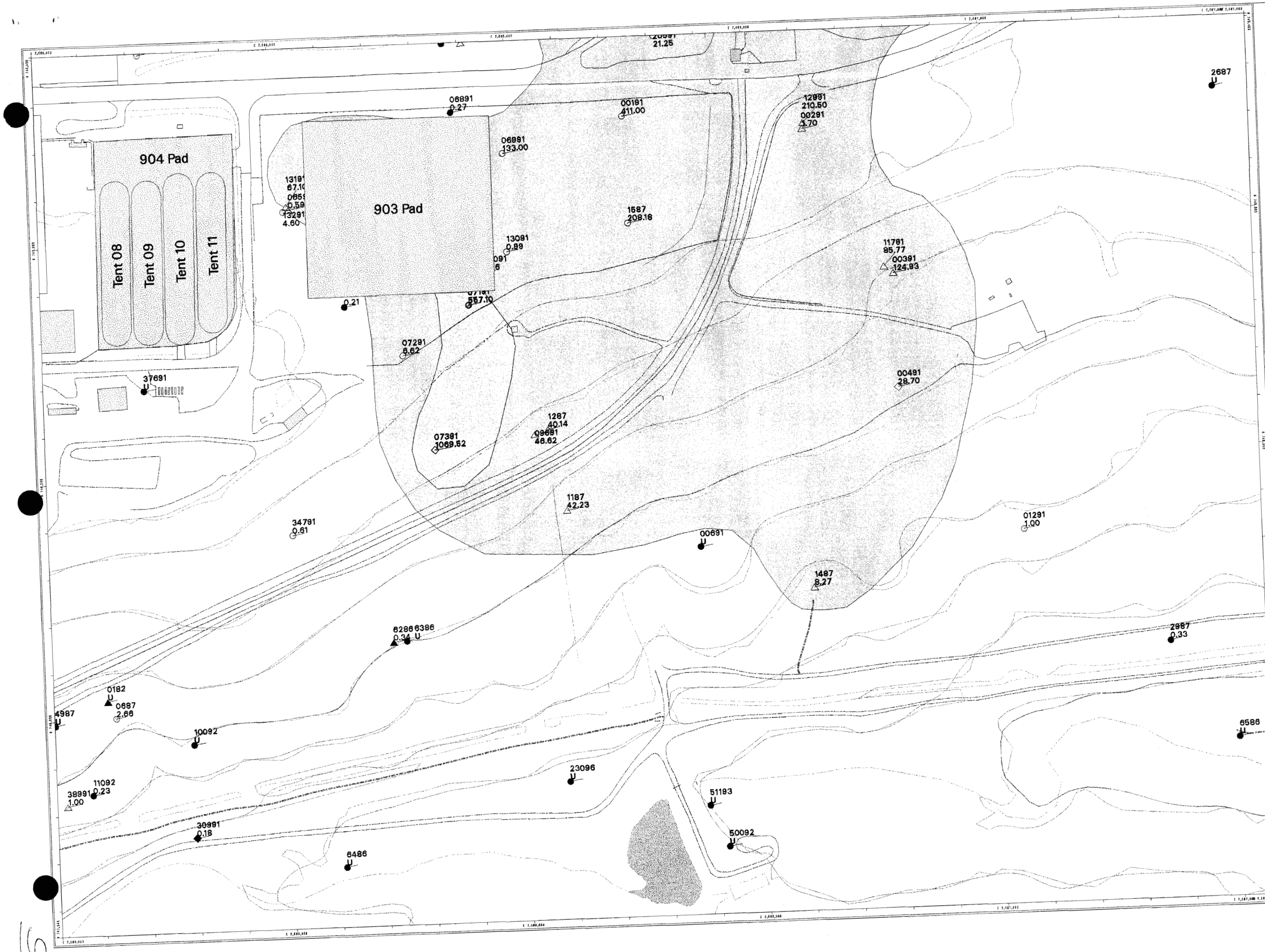
MAP ID: 98-0066

January 07, 1999

/gis2/projects/fy98/98-0066/ac_cci4_plume.aml

15

Figure 2-4
Tetrachloroethene Concentration in Groundwater, 1991-1997 (Avg.)



EXPLANATION

- Tetrachloroethene concentration equal to or greater than 5 ug/L
- Tetrachloroethene concentration equal to or greater than 500 ug/L

Tetrachloroethene Concentration (ug/L)

- Undetected
- 0 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 100
- 100 - 500
- > 500
- Alluvial Wells
- Bedrock Wells
- Alluvial/Bedrock Wells

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial flyover data captured by ERB/ RSI, Las Vegas.
Digitized from the orthophotographs, 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 2300
1 inch represents approximately 192 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

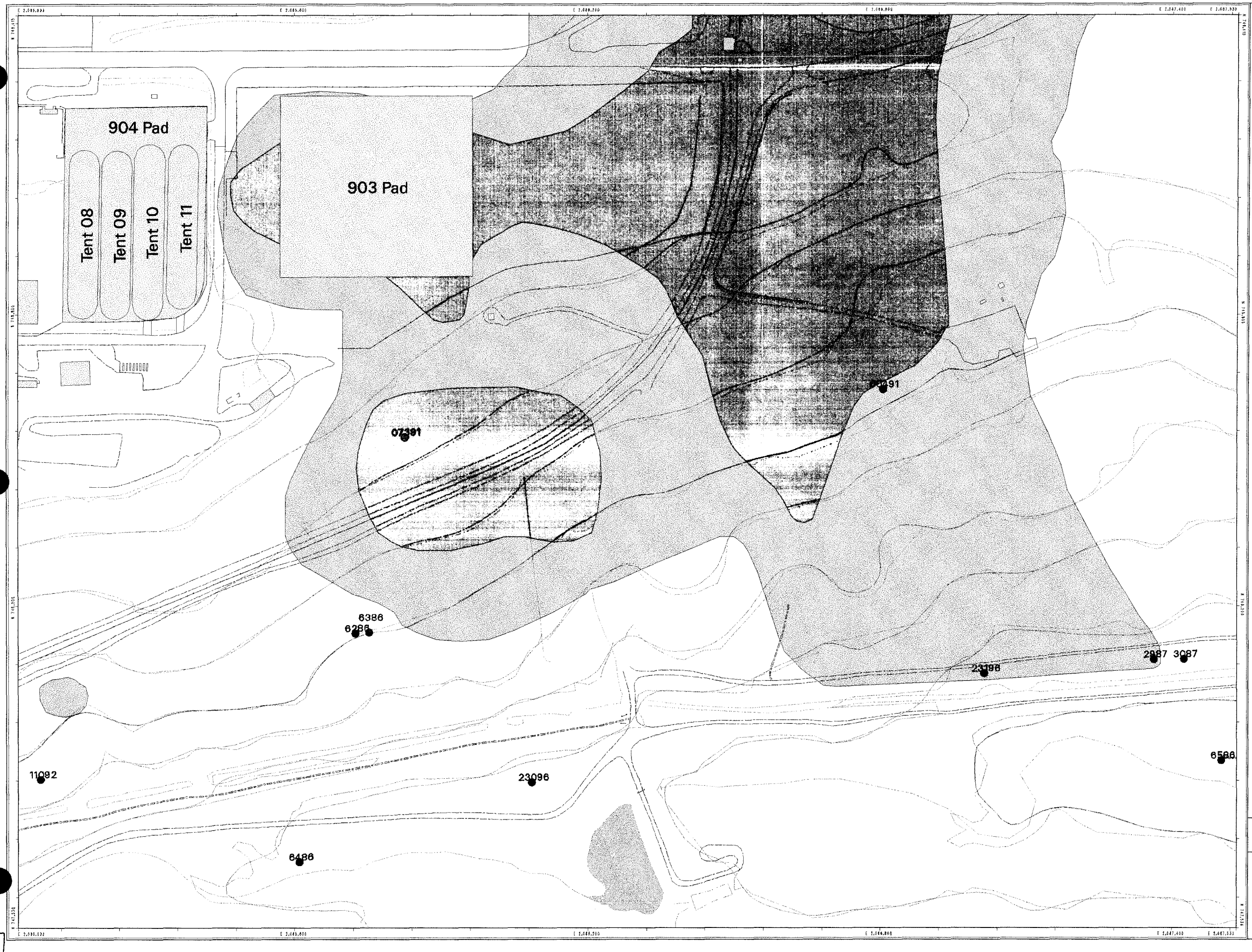
Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 98-0068

January 06, 1999

/gis2/projects/ky99/99-0068/ac_pce_plume.aml

Figure 2-5
VOC Composite Plume Map



EXPLANATION

- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- IMP Water Quality Monitoring Wells

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RMSE, Las Vegas.
Digitized from the orthophotographs, 1995.
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 2330
1 inch represents approximately 194 feet

50 0 100 200ft

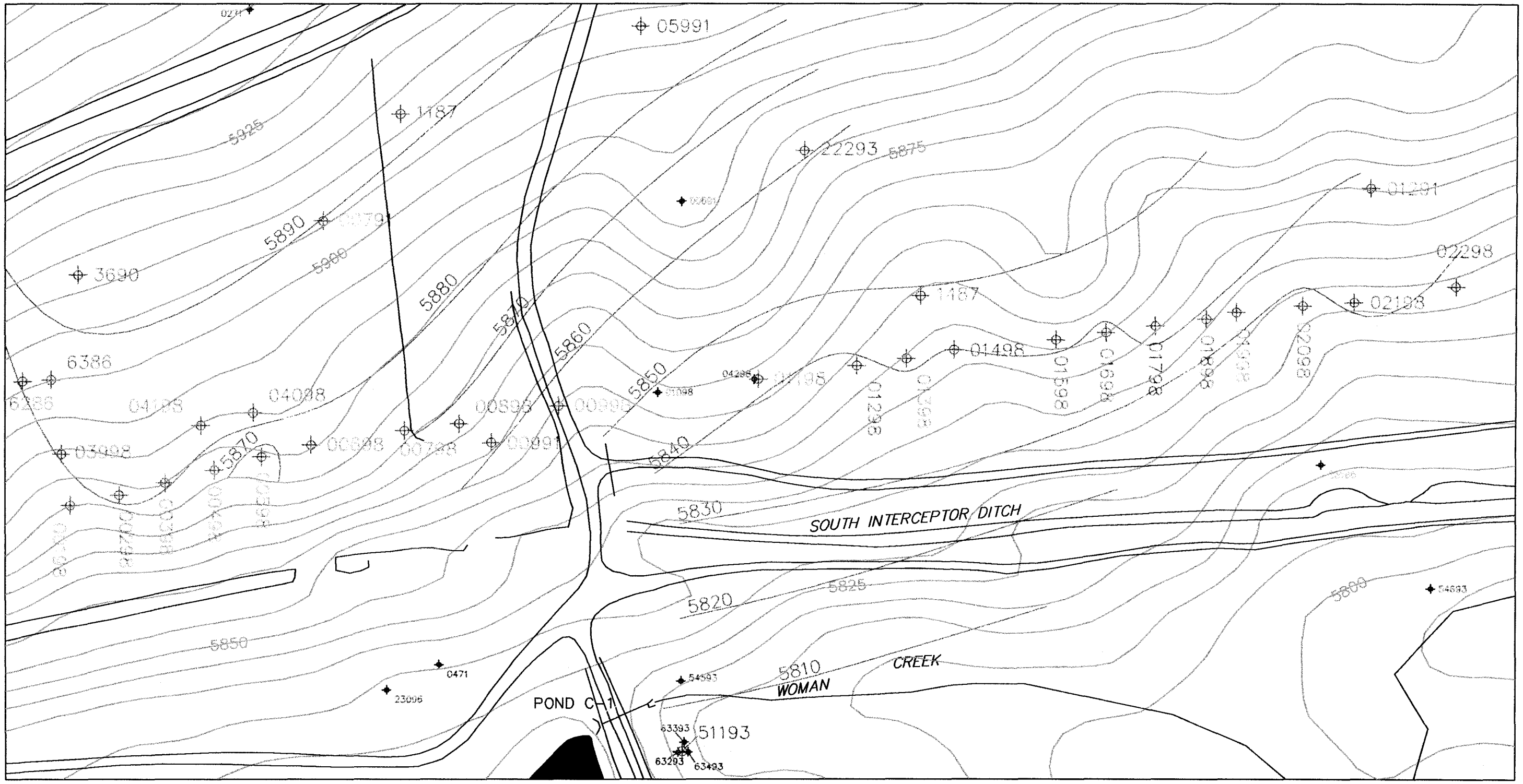
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0066
January 06, 1999

/gis2/projects/fy99/99-0066/voc_comp_plm98.aml



LEGEND

- LAKES AND PONDS
- STREAMS AND DITCHES
- FENCE OR OTHER BARRIER
- DIRT ROAD
- 5 FOOT SURFACE CONTOUR
- 5940 — TOP OF BEDROCK ELEVATION CONTOUR
- 00898 — WELL LOCATION SHOWING BEDROCK ELEVATION
- 00991 — EXISTING DATA LOCATION

GRAPHIC SCALE
0 25 50 100
(IN FEET)
1 inch = 100 ft.

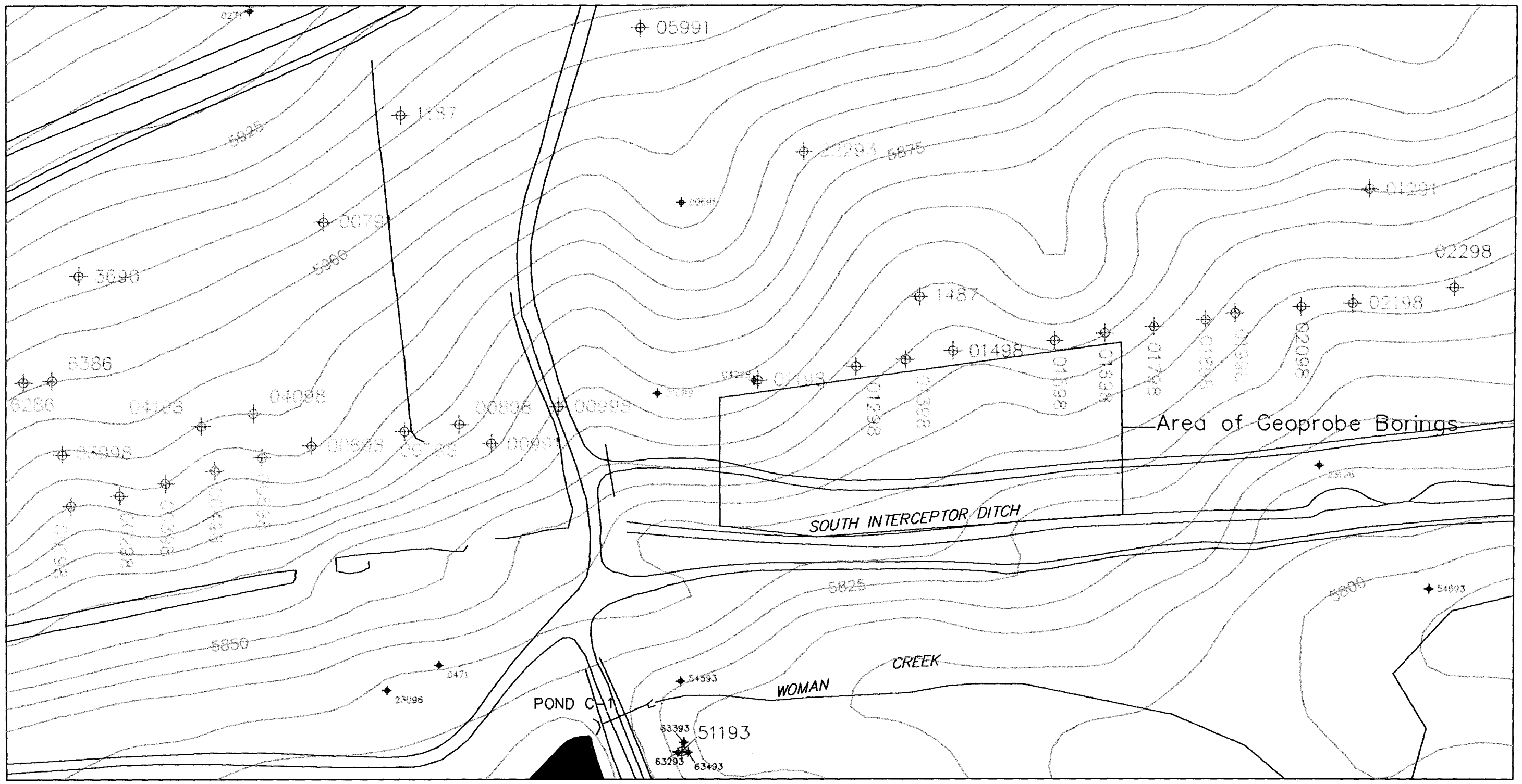
PREPARED FOR:
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
Golden, Colorado

FIGURE 2-6

TITLE:
TOP OF BEDROCK MAP
IN THE 903 PAD/RYAN'S PIT
PLUME STUDY AREA

99-0066/FI 2-6.dwg

20



LEGEND

- LAKES AND PONDS
- STREAMS AND DITCHES
- FENCE OR OTHER BARRIER
- DIRT ROAD
- 5 FOOT SURFACE CONTOUR
- 00898 — WELL LOCATION SHOWING BEDROCK ELEVATION
- 00991 — EXISTING DATA LOCATION

GRAPHIC SCALE
0 25 50 100
(IN FEET)
1 inch = 100 ft.

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Golden, Colorado

FIGURE 3-1

TITLE:
GEOPROBE BORING LOCATION MAP

96-9900/fig2-6.dwg